IOWA HIGHWAY RESEARCH BOARD (IHRB)
Minutes of July 21, 2011

Regular Board Members Present

A. Abu-Hawash	D. Ahart
V. Dumdei	J. Joiner
J. D. King	R. Knoche
J. Moellering	E. Steffensmeier
W. Weiss	R. Younie

Alternate Board Members Present	**Members with No Representation**
R. Fangmann for C. Schloz	J. Alleman
K. Jones for J. Berger	M. Nahra
D. Miller	D. Schnoebelen

Secretary - M. Dunn

Visitors

Ken Dunker	Iowa Department of Transportation
Halil Ceylan	Iowa State University
Terry Wipf	Iowa State University
Chris Williams	Iowa State University
Shashi Nambisan	InTrans/ Iowa State University
Keith Knapp	InTrans/ Iowa State University
Dale Harrington	CP Tech Center at Iowa State University
Brian Keierleber	Buchanan County

The meeting was held at the Iowa Department of Transportation Ames Complex, Materials East/West Conference Room, on Friday, July 21, 2011. The meeting was called to order at 9 a.m. by Vice Chairperson John Joiner with an initial number of 11 voting members/alternates at the table.

Agenda
No changes were made to the Agenda.

Motion to approve Minutes from the May 20, 2011 meeting by D. Ahart. 2nd by E. Steffensmeier.
Motion carried with 11 aye, 0 nay, 0 abstaining.

***M. Dunn introduced new staff and their positions with the Iowa DOT Research & Technology Bureau.

*** One Member Joined the Table***

PROPOSAL , "Bridge Damage Detection: Integration of Structural Health Monitoring System Concepts and Components—A Statewide Collaboration”," Terry Wipf, Iowa State University/InTrans ($303,433)

BACKGROUND
Although bridge testing has been an important tool for evaluating structures for several decades, it has only been within the last decade that specific effort has been given to develop systems that are capable of operating in an autonomous fashion. Beginning 2002, the Iowa State University Bridge Engineering Center began a project to evaluate the State of Iowa’s first bridge constructed with High Performance Steel (through the FHWA’s Innovative Bridge Research and Construction program) (Wipf, et a., 2006). One of the objectives of that work was to further the State’s expertise in long-term bridge monitoring. This initial effort was the first major, concerted effort to handle large amounts of performance data. A large amount was learned during this project. Principally, an algorithm was developed that allowed for the

automated removal of temperature effects. This represented a significant step in the development of a long-term monitoring system.

Following on the success of the 2003 project, the Bridge Engineering Center embarked on a project to specifically develop an algorithm capable of autonomously detecting damage in the nearly 50 fracture critical girder bridges in Iowa (Wipf, et al, 2007). That work resulted in the foundation of a complete, turn-key system. The system operates on the assumption that pairs of data can be assembled from sensors located throughout a bridge and that the relationship between the sensors can be established and is reliable as long as no damage occurs to the bridge. And thus, damage can be detected when the relationships no longer predict the response. An analytical evaluation of the developed algorithm revealed that variability in truck parameters (e.g., number of axles, weight, speed, etc.) created scatter in the relationships. Further work to refine the system resulted in an algorithm that accounted for truck variability and analyzed the data in a strong statistical manner. A follow-up analytical evaluation gave further evidence that the developed algorithm was likely to be able to detect bridge damage (Lu, 2008).

A study completed in November 2010 sought to experimentally validate the developed algorithms. During that study sacrificial specimens (which simulated the likely damage locations) were installed on an actual bridge (Phares, et. Al, 2010). The sacrificial specimens were exposed to real traffic loads and had two types of damage induced: fatigue cracks and thickness loss. It was found that the damage detection algorithm was able to detect 100% of the damage cases. However, it was also found that the algorithm had a relatively high false detection rate. Accordingly, improvements to the algorithm were investigated and evaluated.

Also completed in 2010 was a project to develop a damage detection tool based upon vibration-based techniques. This work, completed by the University of Iowa, consisted of testing using numerical simulations, laboratory experiments, and field testing. Much was learned about using vibration-based techniques. Although it was found that the proposed methodologies are not ready for implementation, 2
there is strong evidence that integration of vibration measurements into the Iowa State University technique may enhance the overall damage detection capabilities.

Work completed at the University of Northern Iowa, also completed in 2010, sought to evaluate the feasibility of using wireless sensor systems for transportation system monitoring. Because a significant cost of any bridge monitoring system lies in the cost of cabling and its installation this work is of great importance to the widespread use of bridge monitoring. Several recommendations were developed as part of that work which may enhance the robustness of the overall systems under development: (1) system modification for the measurement of lower sample rate sensors and (2) development of energy harvesting systems.

BENEFITS
You can deliver a product in two years that will be the fruits of the labor from all three universities working together, and it is going to build on a mature health monitoring system that already exists at Iowa State University.

OBJECTIVES
The objective of this project is to bring together various components of recently completed research at the State of Iowa's Regent Universities for the Iowa DOTs benefit. The specific objectives are:
Objective 1: Final development of the overall SHM system hardware and software
Objective 2: Integration of vibration-based measurements into current damage detection algorithm
Objective 3: Evaluation and development of energy harvesting techniques

Q: Regarding energy harvesting: How does this compare to future technology or projects that have been done already?
A: There are things out there, but nothing is acceptable to our current requirements.

Motion to Approve by W. Weiss. 2nd by V. Dumdei.
Motion carried with 12 aye, 0 nay, 0 abstaining.

FINAL REPORT TR-575, "Embedded (MEMS) Micro-Electromechanical Sensors & Systems for Monitoring Highway Structures & for Infrastructure Management," Halil Ceylan, Iowa State University/InTrans ($100,000) (15 mins) – [This project was funded under the IHRB Innovative Projects Program]

BACKGROUND
The development of novel "smart" structures by embedding sensing capabilities directly into the construction material during the manufacturing and deployment process has attracted significant attention in the context of autonomous structural health monitoring (SHM). Advancements in micro-electromechanical sensors and systems (MEMS) technology and wireless sensor networks provide opportunities for long-term, continuous, real-time SHM of pavements and bridges at low cost within the context of sustainable infrastructure systems.

OBJECTIVES
The primary objective of this research was to investigate the use of MEMS in highway pavement infrastructure for SHM purposes. This study focused on investigating the use of MEMS and their potential applications in portland cement concrete (PCC) through a comprehensive literature review, a vendor survey, and a laboratory study. These were the specific objectives of this study:

- Ascertain the "technology readiness level" of MEMS technology for deployment in highway pavement infrastructure through a comprehensive literature review and vendor survey.
- Demonstrate the feasibility of using off-the-shelf, market-ready, prototype MEMS in PCC in the laboratory to monitor the physical properties of concrete, such as temperature, moisture, and strain.
- Provide recommendations to the Iowa Department of Transportation (DOT) for future research and implementation of potential MEMS-based highway infrastructure applications.

BENEFITS
Continuous monitoring and cost-effective assessment of infrastructure systems can help engineers to estimate risk at different stages and more efficiently plan maintenance and rehabilitation activities during the life-cycle of these structures. The development of novel "smart" structures by embedding sensing capabilities directly into the construction material during the manufacturing and deployment process has attracted significant attention in the context of autonomous SHM. Advancements in MEMS technology and wireless sensor networks provide opportunities for long-term, continuous, real-time SHM of pavements and bridges at low cost within the context of sustainable infrastructure systems.

Q: Did you subject any of the sensors that went into the cube to any mixing action?
A: Yes we did. They are extremely durable and are packaged in a plastic casing. They have gone through a couple of thousand cycles and are still in really good condition.

Motion to Approve by R. Younie. 2nd by R. Fangmann.
Motion carried with 12 aye, 0 nay, 0 abstaining.

PROPOSAL TR-575 Phase II, " Development of a Wireless MEMS Multifunction Sensor System and Field Demonstration of Embedded Sensors for Monitoring Concrete Pavements", Halil Ceylan, Iowa State University/InTrans ($248,959)

BACKGROUND
The purpose of this Phase II research study is to develop a wireless MEMS multifunction sensor capable of real-time, remote monitoring of both strain and moisture content in concrete to facilitate multiple transportation infrastructure applications. Such a system should be capable of continuously monitoring the physical properties of concrete pavements that relate to the onset of distress.

OBJECTIVES
Wireless multi-sensor networks are promising in that they have the potential to monitor structural health, supporting efficient operation and maintenance of civil infrastructure through simultaneous measurement of multiple properties. Primary objectives of the proposed research is twofold: a) Develop a wireless MEMS multifunction sensor (WMS)

system capable of real-time, remote monitoring of strain, moisture content, and temperature in pavement concrete, b) Deploy some of the promising off-the-shelf RFID tags and sensors developed for monitoring concrete pavements in a live field project.

BENEFITS
Continuous monitoring and cost-effective assessment of infrastructure systems can help engineers estimate risk at different stages and more efficiently plan maintenance and rehabilitation activities during the life-cycle of these structures.
Wireless transmission of temperature data to construction staff can directly to alert them to freezing or elevated curing temperatures; development of future concrete strength forecasting models; monitor cold or hot weather effects on mix designs using certain materials, strength gain in concrete bridges, etc.; characterize early-age PCC curling behavior, etc.
Measurement of localized strain will be useful for pavement early damage detection and future condition evaluation. The strains measured by the proposed WMS could be used to estimate the remaining fatigue life using Miner's hypothesis in the context of mechanistic-empirical pavement design.

Q: Does it have to be put into new construction or existing structures?
A: You can use it in both.

C: I am concerned with the data management aspect of this project. In order for the data to be useful in the future for determining the causes of distress in a pavement, there needs to be someone managing the data for future retrieval. I don't foresee a time where we will have continuous data for hundreds of miles of roadway to go back and look at those problems when they occur or to even prevent them from occurring.
A: We currently have the capability to handle large amounts of data. That can be maintained by a computer program.

C: How will the system be powered?
A: They can be actively powered or passively powered. Passive systems will require going and reading the sensors where active systems will be able to send the data.

Q: As far as putting sensors in new pavement, would they survive putting them in asphalt pavement or would you put a patch in the asphalt and put the sensor in.
A: Yes it does work for both. It is more challenging to make it work in plastic concretes because of the presence of water.

Motion to Approve by V. Dumdei. 2nd by J. D. King.
Motion carried with 12 aye, 0 nay, 0 abstaining.

PROPOSAL for Additional Funding, LTAP Bridge Inspection Training Program, Keith Knapp, Iowa State University/InTrans ($3,698)

This bridge inspection training effort (which may include multiple courses or offerings each year) was unanticipated in the 2011 LTAP funding proposal. Iowa LTAP would like to request a 2011 funding increase of $3,698 to support the organization and planning activities related to the bridge inspection training program.

Motion to Approve by W. Weiss. 2nd by R. Knoche
Motion carried with 12 any, 0 nay, 0 abstaining.

First Round RFP Review and Discussion FY 11-12 (45 mins)

a. IHRB-11-01, Development of Bio-Based Polymers for Use in Asphalt
    ***Motion to Approve** without change by R. Knoche, 2nd by B. Younie. Motion carried with 12 any, 0 nay, 0 abstaining.

b. IHRB-11-02, Optimizing Pavement Base, Subbase, and Subgrade Layers for Cost and Performance on Local Roads

*Jack Moellering will serve as Technical Contact

* **Motion to Approve** by W. Weiss, 2nd by J. Moellering. Motion carried with 12 any, 0 nay, 0 abstaining.

c. IHRB-11-03, Reflective Crack-Mitigation Guide for Asphalt

* **Motion to Approve** without change by D. Ahart, 2nd by R. Fangmann. Motion carried with 12 any, 0 nay, 0 abstaining.

d. IHRB-11-04, Preventing Random Cracking through Proper Design and Concrete Mixes

* Technical Contact to Be Determined. Maybe Kevin Jones (Materials) or Kevin Merryman (Construction)

*This problem statement came from the 2008 CP Tech Center focus group. Recently the Iowa DOT has been experiencing some longitudinal cracking in the outside wheelpath of our wider, 14 ft lanes. There was some interest in widening the scope to include investigating that issue as well.

* **Motion to Approve** including longitudinal cracking in the outside wheelpath of wider lanes by R. Younie, 2nd by E. Steffensmeier. Motion carried with 12 any, 0 nay, 0 abstaining.

e. IHRB-11-05, Pilot Project for a Hybrid Road-Flooding Forecasting System on Squaw Creek

*Younie likes the concept but is concerned about the funding.

*Matching funding from the Iowa Flood Center, USGS, and FEMA will be investigated

*If Dave Claman is not available, Joiner will serve as Technical Contact.

* **Motion to Approve** by W. Weiss, 2nd by R. Younie. Motion carried with 12 any, 0 nay, 0 abstaining.

2011 County Engineer's Focus Group Summary and Discussion of County Research Topics, Vanessa Goetz, Secondary Road Research Engineer, Iowa DOT .

A summary of the focus group was presented and there was discussion of possible County research projects to be developed. Two possible projects were identified and a preliminary literature search will be developed for review by the Board.

*No formal action.

NEW BUSINESS

Accelerated bridge construction workshop to be held in Pottawattamie County in late October; date to be determined.

ADJOURN

Motion to Adjourn by J. D. King. 2nd by R. Knoche.
Motion carried with 12 aye, 0 nay, 0 abstaining.

The next meeting of the Iowa Highway Research Board will be held Friday, September 30, 2011, in the East/West Materials Conference Room at the Iowa DOT. The meeting will begin promptly at 9 a.m.

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Mark J. Dunn, IHRB Secretary